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Proceedings of the Maritimes Region Science Advisory Process on the Recovery Potential Assessment of Cusk (*Brosme brosme*)

27-29 November 2007

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

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May 2008

Compte rendu de la réunion du Processus consultatif scientifique de la Région des Maritimes au sujet du potentiel de rétablissement du brosme (*Brosme brosme*)

Du 27 au 29 novembre 2007

Institut océanographique de Bedford,
Dartmouth (Nouvelle-Écosse)

Tana Worcester[1] et Kent Smedbol[2]
coprésidents de la réunion

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mai 2008

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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SUMMARY

A Maritimes Region Science Advisory Process (SAP) was conducted on 27–29 November 2007, at the St. Andrews Biological Station in New Brunswick to conduct a recovery potential assessment for cusk (*Brosme brosme*). Participation in this meeting included Fisheries and Oceans Canada (DFO), non-DFO scientists, Nova Scotia Department of Fisheries and Aquaculture, aboriginal communities, and non-governmental organizations (NGOs). The results of this meeting are expected to be considered in the listing decision for cusk.

SOMMAIRE

Dans le cadre du Processus consultatif scientifique de la Région des Maritimes, on a tenu une réunion du 27 au 29 novembre 2007, à la Station biologique de St. Andrews, au Nouveau Brunswick, afin de procéder à une évaluation du potentiel de rétablissement du brosme (Brosme brosme). Y participaient des membres du personnel de Pêches et Océans Canada, (MPO), des scientifiques de l'extérieur du MPO, ainsi que des représentants du ministère des Pêches et de l'Aquaculture de la Nouvelle Écosse, de communautés autochtones et d'organisations non gouvernementales (ONG). Il devrait être tenu compte des résultats de la réunion dans la décision qui sera prise au sujet de l'inscription éventuelle du brosme sur la liste des espèces en péril.

INTRODUCTION

R. Stephenson, the Director of the St. Andrews Biological Station (SABS), began the Recovery Potential Assessment (RPA) for cusk by welcoming participants (Appendix 3) to SABS. K. Smedbol, a co-chair, touched upon some administrative issues and began a round of introductions. T. Worcester, the other co-chair, provided a brief introduction to the meeting. She noted that this was a science advisory meeting and, as such, would be focussed on the development of science advice rather than on the management implications of the advice. Everyone was invited to participate fully in the discussion and contribute knowledge to the process, with the intent of delivering a scientifically defensible product. The external peer reviewers, C. Minto from Dalhousie University and L. O'Brien from the National Marine Fisheries Service (NMFS), were then introduced. T. Worcester noted that due to unfortunate timing, the meeting was being held during the start of the lobster fishery and was likely the reason for limited industry participation. The Terms of Reference for the meeting were reviewed (Appendix 1), including the objectives of this meeting, which were to:

Phase I: Assess Current Species Status

1. Evaluate present species status for abundance, range, and number of populations.
2. Evaluate recent species trajectory for abundance, range, and number of populations.
3. Estimate the amount and type of habitat that is necessary for survival and recovery.
4. Estimate potential recovery targets (including abundance and distribution).
5. Project expected population trajectory over 3 generations (or other biologically reasonable timeframe) given current population dynamics parameters and associated uncertainties, assuming only natural mortality.
6. Estimate how time to recovery targets would change at various levels of mortality or productivity.
7. Evaluate residence requirements, if any.

Phase II: Scope for Management to Facilitate Recovery

8. Quantify, to the extent possible, the risk (including likelihood, severity and uncertainty) of each major potential source of mortality/harm identified in the pre-COSEWIC RAP or COSEWIC Status Report. Where it is not possible to determine the absolute magnitude of each risk, determine the relative impact of these risks on survival and recovery.
9. Inventory, to the extent possible, all reasonable and feasible activities that could increase productivity or survivorship.
10. Evaluate to the extent possible the likelihood that habitat is currently, or is likely to become, a limiting factor to achieving recovery targets identified in 4.
11. Assess, to the extent possible, the magnitude by which current threats to habitat have reduced habitat quantity and quality.

Phase III: Scenarios for Mitigation and Alternative to Activities

To the extent possible with the information available,

12. Inventory all feasible measures to minimize the impacts of activities in task 8 and 11.
13. Inventory all reasonable alternatives to the activities in tasks 8 and 11, but with potential for less impact (e.g., changing gear in fisheries causing bycatch mortality, relocation of activities harming critical habitat).
14. Document the expected reduction in risk to survival and recovery if the mitigation measures described in task 12 were implemented.
15. Document the expected reduction in risk to survival and recovery if the alternatives to the activities described in task 13 were implemented.

The Agenda (Appendix 2) was reviewed, and nothing further was added.

REVIEW OF THE STATUS OF CUSK

Day One: November 27, 2007

Recovery Potential Assessment for Cusk, *Brosme brosme*: Phases I and II
L. Harris, DFO Maritimes Science

Presentation Highlights:

The presentation on the status of cusk started with a description of its distribution and habitat requirements, including its global and Canadian distribution, the depth at which it is typically found, and preferred habitat types. Predators and prey of cusk were also described. Known life-history characteristics include a 50% maturity of around 41 cm and a maximum age of about 40 years. A brief description of the fishery was provided, and it was noted that cusk are caught primarily in the groundfish longline fishery. The evaluation of cusk by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC) as threatened, and the process to date for the consideration for listing under the *Species at Risk Act* (SARA) were also described.

The analysis of existing information indicated that there is no reliable estimate of abundance and no directed survey for this species. Information on cusk distribution and abundance has come primarily from longline landings in Northwest Atlantic Fisheries Organization (NAFO) Division 4X, the halibut longline survey and the 4VsW sentinel survey. Information is now also being gathered from the lobster fishery in southwest Nova Scotia. Estimates of catch per unit effort (CPUE) were determined from the groundfish longliners in 4Xnopqu of tonnage classes 2 and 3 to get good time series. There has been a decline in landings over time, which may reflect changes in management, as well as declines in abundance. CPUE is 42% lower in 1999 than in previous years. In an analysis of data from July to September only, CPUE has declined and is now stable, or declining. There has been no apparent change in distribution, as cusk continue to be widespread and common.

Results from a study to investigate cusk bycatch in the lobster fishery were reported. Results indicate that 1 cusk is caught for every 8 traps in the offshore, 1106 traps in the inshore, 39 traps in the nearshore, and 55 traps in the midshore. There was a total catch of 461 mt of cusk in Lobster Fishing Area (LFA) 34 and 25 mt in LFA 41 (2005/2006). Mortality rates were determined to be 49% in LFA 34 and 89% in LFA 41. This was considered to be an underestimate. No bycatch estimates have been done for other LFAs or for other invertebrate fisheries.

Finally, information on cusk was presented based on the halibut industry longline survey. Cusk landings in this survey were highest in 2007. There has been no trend in CPUE since 1998 and no apparent change in the distribution of cusk within the range of this survey.

Discussion:

Someone asked what the normal lobster fishing season was for LFAs 34 and 41. L. Harris explained that the fishery extended to end of May, but the second study did not include the last couple of months. She could have applied the bycatch rates to the other months, but chose only to estimate rates in months for which data had been collected.

Someone asked about the use of cusk as bait in the lobster fishery. L. Harris indicated that there was no data to support this claim, but she had heard it anecdotally from a variety of sources.

A question was raised about the source of the cusk distribution map. L. Harris noted that it was derived from a variety of sources, including the research vessel (RV) survey and halibut survey. She did not filter for errors.

L. Harris was also asked about the westward range of cusk. She indicated that cusk distribution does not extend very far west.

In response to a question about whether different cusk stocks had been identified, L. Harris noted that there was as yet no evidence to suggest that there is more than one stock.

Recently, the state of Maine did a longline survey, but the results of this survey have not been reported. Otter trawls are not very effective at catching cusk, but the halibut longline survey caught just as much cusk as halibut. Not many cusk are observed in the Gulf of Maine, likely because of the wrong sampling gear. Cusk are said to have been caught in gillnets in Gagetown, New Brunswick.

It was suggested that other Canadian survey data should be included in the Canadian distribution. L. Harris noted that only 2 records were available from the Gulf of St. Lawrence and 26 records were available from Newfoundland. Some information might have been available from Newfoundland observer records, but when asked, the observer thought that cusk might have been misidentified. This was unexpected since cusk are very distinctive fish, and it is unclear what they might have been confused for. L. Harris tried to get samples from the commercial fishery for genetic studies, but was only able to obtain 1 sample. In conclusion, cusk do occur in other areas, but not commonly. It was unclear where FishBase (www.fishbase.org) got its information on cusk distribution.

L. Harris noted that genetic work on cusk is underway. She has been in contact with colleagues in the northeast Atlantic, and some of their results have been compared to those from Canada. Preliminary genetic results indicate that the cusk population found in the northeast Atlantic may be a different population from that in Canada, but these results have not yet been published.

It was noted that the maximum life expectancy of cusk of 40 years was based on 1 fish that was 82 cm. There are records of cusk as long as 118 cm. One would expect the true maximum age to be older than 40 years. Colleagues in Norway were not surprised that fish in cold waters would live as long as 40 years.

It was suggested that 2 outliers were unduly influencing the graph of length at maturity. The location of these samples was questioned. L. Harris responded that all samples (more than 1000 fish) were from same area, including the eastern shelf. All were from port sampling and RV surveys (20 fish). It is possible that resting and immature cusk might be confused, although removing fish identified as "resting" did not change the analysis significantly. This was considered to be a preliminary analysis, and conclusions should not yet be drawn from this work.

Someone asked whether there had been any signs of flip-flopping in the size of maturity (i.e., reversing of the male and female size at maturity) in Norway. L. Harris did not know. Published data from this region has shown both sexes plotted together. If this result is not a sampling problem, then it was suggested that the Norwegians should be asked whether they have observed a similar pattern.

It was suggested that it would be interesting to digitize Oldham's (1966) data and refit.

Potential changes on length frequencies over time were discussed. It was agreed that the full length range of cusk continues to be present, but there may have been some shift in the length frequencies. This shift may be a result of changes in the distribution of the fishery, as the longline fishery does not go everywhere that it used to anymore. For examples, the fishery seems to have been catching bigger fish in the 1970s and 1980s. Was there offshore fishing then? Yes, there was a shift offshore and then back inshore. There also used to be a much larger catch in Div. 4VW. Ninety percent of the catch now comes from Div. 4X and from small boats. The greatest reduction in effort has been in Div. 4VW, and there were probably deeper landings from Div. 4VW than there are now. It was noted that the length frequencies that had been presented were only from Div. 4X. However, it was felt that there were still large difference in effort and change in the pattern of activity.

L. Harris noted that no large differences were seen in the lengths of cusk from different areas during the lobster bycatch study, though length frequencies were not investigated. The study did see a large range in the size of cusk encountered, and it appeared that large cusk were not excluded from lobster traps. It was noted that traps are a little bigger in the offshore, however. It was suggested that the proportion of large cusk caught inshore versus offshore might be interesting to investigate at some later date. In addition, it might be possible to apply the length/weight relationship developed elsewhere to the lengths measured during the lobster study.

Someone asked whether the cusk fishery has ever been a directed fishery and whether there has there been a change in the distribution of cusk over time. Changes in the distribution of the fishery were discussed. In the past, the fishery has tended to direct for cod and haddock. However, now industry can get 60 cents for cusk, which is more than they get for cod and haddock. The industry is not going to throw away fish if there is a good price. Cusk is higher value now that it has been previously. Other species have decreased in value. Officially, the cusk fishery is a bycatch only fishery. Thirty years ago, there were a few fishermen that fished specifically for cusk to get large catches. Historically, however, cusk was worth much less. There was a winter fishery for cod, haddock, and pollock on the shelf edge. This fishery is gone now, but it may have had bycatch of larger cusk. Fishermen would be more likely to get large catches of cusk if they were fishing for halibut, with large bycatch of hake.

In the Gulf of Maine, a couple of fishermen had a contract for cusk. That is when the U.S. landings peaked. In time, these fishermen either lost their contract or fished it out, and the landings dropped off. The rest is bycatch.

In response to a question, L. Harris explained that there have been no directed observations or studies to identify the location of cusk spawning and nursery grounds. In addition, small cusk are not often caught in the longline fishery or survey, as the hooks are quite large. Some small cusk have been observed in Iceland. The Scotian Shelf Ichthyoplankton Program (SSIP), which was conducted in 1978-1982, indicated that cusk eggs and larvae were widespread.

It was suggested that the length distribution graph was critical, particularly since it showed a decline. It was also suggested that an investigation of the spatial distribution of this data within Div. 4X could be informative, as well as length frequencies by unit area. Finally, it was suggested that both hypothesis (i.e., that changes in length frequencies were real or were due to changes in the distribution of fisheries) should be included in the working paper. L. Harris noted that this topic had been discussed at previous meetings. There was no agreement that further analysis would yield useful results within the time available.

Discussion continued on how to separate changes in the seasonal and spatial distribution of the fishery over time from changes within the cusk population. In the current analysis, attempts were made to standardize for seasonal changes in the fishery. While CPUE could be investigated for a smaller, more standardized area, CPUE still might not reflect changes in abundance. K. Smedbol reviewed the CPUE analysis that had been done in 2004, which had been rejected, and he noted that the decline curves were quite similar to the current analysis.

Concerns were expressed about conducting analysis for only tonnage classes 2 and 3, as it was unclear what percentage of landings these classes represented, and it was suggested that changes in the fishery would influence results. The proportion of landings from tonnage classes 2 and 3 are small at present. Smaller vessels seem to be targeting cusk in a particular area. If this area is excluded, there appears to be no trend, i.e., see a decline, but not as large a decline. "Standar" was tried, resulting in main effects by area, month, and vessel class. There was disagreement on whether an index that only reflects approximately 10% of the landings would be appropriate. Some felt that this was a large enough proportion to be appropriate. Others felt that it was not the total percentage that was important, but rather the fact that the use of these tonnage classes had changed over time. It was suggested that a table of landings should be presented by tonnage class and by area.

In response to a question about whether CPUE is a useful abundance index, it was suggested that it might be useful from the halibut longline survey but not from the commercial fishery. Someone asked why CPUE had been rejected at previous meetings. In previous meetings, there had been concerns about using CPUE for a non-targeted species. Fishing patterns have changed, and these might not be captured. Because of the cusk cap, there have been change in fishing behaviour to try to avoid cusk. There are also issues around vessels less than 45', pre-1995. Data is better from 1995 onwards, and the pre-COSEWIC assessment (Harris et al., 2002) accepted L. Harris' analysis using this shorter time-frame.

Discussion turned to the halibut survey analysis. One participant was struck by the difference in trends for period of overlap and asked whether halibut catch rates had been analyzed in areas where CPUE trends had been determined. L. Harris responded that she had tried this, but was limited by the small number of stations that were sampled in the same location each year. Other issues with the halibut survey were discussed, including that a single station can be sampled by different vessels, that there can be slight differences in the timing of the survey, and that there is no bait standardization. The frequency of the fixed station survey was also discussed. It was suggested that length frequencies of cusk from halibut survey should be investigated. The possibility of detecting recruitment of cusk from the halibut survey was raised; however, fish are not counted (just weighed) and, therefore, it would be unlikely to detect recruitment. However, a request was made to collect more information on cusk during the halibut longline survey this year and samplers were happy to comply.

Someone asked what decline in abundance would be required to see a change in distribution. It was suggested that if a population were uniformly distributed in space, one could resample and see what prevalence would be with different levels of abundance. In this case, most of the distribution data are from commercial landings. Cusk aggregation or concentration is not apparent from this data source. It was noted that the RV bottom trawl survey showed a change in cusk distribution, but commercial landings did not reflect this change. The influence of depth on cusk distribution was discussed. It was agreed that changes in the local-scale distribution (i.e., within a fishing area) and abundance of cusk would be correlated, and analysis of these local-scale changes in cusk "distribution" may be more relevant to the discussion of changes in abundance than to a discussion of changes in range. It was suggested that cusk are still are caught everywhere throughout their range. However, the spatial extent of cusk was 80% within

its range and not 100%, so there are places where cusk are not caught. L. Harris noted that the detailed spatial analysis was only conducted for Div. 4X and did not include Div. 5z. It would be relevant to know if cusk are all concentrating in one area. It may also be useful to determine if local-scale effects of fishing could be detected through detailed spatial analysis. It would be possible to look at smaller areas, but it was suggested that it would be unwise to rely on logbooks for a finer scale than what has been presented.

Discussion immediately after lunch focused on the bycatch analysis. L. Harris started by acknowledging the fishermen who contributed to this project. Someone asked why the LFA 34 trips were special and why observer information from LFA 41 was not used. L. Harris responded that sampling effort was quite low, and she did not want to include this information because fishing methods may have been different.

Clarification was requested on the determination of mortality rates. L. Harris reminded participants that mortality was determined through at-sea sampling, and it reflected a visual determination of whether a cusk was dead or in very bad condition upon release. She would expect there to be some additional mortality after cusk were released, so this is considered to be an underestimate of total mortality.

It was suggested that bycatch estimates could be expanded into LFA 41 if you were to assume that catch rates were the same for other areas. Discussion ensued on whether a comprehensive picture of cusk mortality was required for the RPA. It was agreed that while all known sources of mortality should be considered, we should not just guess additional sources of mortality. Someone requested a table with lobster fishing effort to compare to crab fishing effort. The RPA can note an overlap in space between various activities and cusk distribution.

L. Harris noted that she had presented this information to LFA 34, and they had expressed concerns about extrapolation even within the areas sampled. It was noted that the relationship between cusk catch and lobster catch was unknown. Representatives from Maritimes Region Fisheries and Aquaculture Management (FAM) Branch were comfortable with the analysis as presented.

Possible next steps could include stratum-weighted spatial analysis pro-rate for years. As yet, there is no breakdown for mortality by stratum.

It was suggested that there should be some consistency in determining mortality rates across fisheries (e.g., in assumptions about mortality after release).

It was recommended that a list of fisheries for which cusk bycatch analysis had been conducted should be presented within the supporting documentation. In addition, a figure that showed the distribution of effort by fishery would also be useful.

Population Models for the Recovery Potential Assessment of 4VWX Cusk
T. Davies, Dalhousie University, and I. Jonsen, DFO Maritimes Science
Presented by I. Jonsen

Presentation Highlights:

Data sources included the bottom trawl RV survey from 1970-2007, the 4VsW sentinel survey from 1995-2003, and the 4VWX halibut longline survey from 1999-2005/2007. A stage-structured model would have been preferable, but the catchability of juvenile cusk is close to zero. Instead, they used a surplus production model (SPM). Model was attempted using all the

surveys, then it was tried just using the sentinel and halibut survey to see what information could be gathered. A stochastic exponential model (SEM) was also attempted.

Results indicated that fish caught in the halibut longline survey are larger. The SPM and SEM models gave similar declines in cusk abundance. There was little evidence in a change in catchability prior to 1991 as compared to post-1991, and landings seem to reflect the RV survey quite well. It was noted that the next draft of the working paper will include more consistent use of medians versus modes.

Ageing information indicated an age at 50% maturity of approximately 10 years, and the maximum age is likely well over 40 years. A generation time of 15 years was used. There appears to be a reduction in the length at maturity of females in Div. 4X, but this has not been verified should only be considered as an issue for further investigation.

If r is underestimated, then based on the model projections presented, recovery of cusk may be possible with 750 mt of reporting landings. Recovery would be possible with 1500 mt of reported landings only if r is grossly underestimated.

In conclusion, the estimate of the carrying capacity of the population (K) is not great. This makes is hard to get an estimate of absolute biomass. Modeling provides a pretty good estimate of *r*, but it is most likely underestimated.

Discussion:

A comparison was made between the data sources used in the opening presentation and the data sources used in the modeling. Clarification was requested on the exclusion of the sentinel survey from the opening presentation. L. Harris responded that there had been reductions in the number of sentinel survey sets over time (from 250 to only 50 sets), and she suggested that information on cusk from the halibut survey is better.

Someone asked whether there is evidence that captains are moving away from rocky strata. It was suggested that they do avoid rocky areas, e.g., German Bank, and coastal areas. Within the overall research vessel survey area, the RV survey is random. However, if a specific station is too rocky, it is not completed. It was suggested that there have been no increases in any fish species with Div. 4VW since the moratorium. The Coast Guard has been pickier about where they put their sets, so they get fewer tear-ups. There is no evidence that there have been consistent changes over time. However, any changes are more likely to have occurred since 1991. The RV survey may be a good indication of cusk biomass trends on sand, but it may not reflect biomass trends on rocks. Tear-ups were not recorded until quite recently.

These potential changes in methodology were not considered by some participants to be sufficient to explain what happened to cusk since 1991. The things that changed were not expected to affect the catch of something like cusk, which stays close to the bottom. Other than in 2004, where major changes were made for 1 year, the survey was expected to have fished the same for something that stays close to the bottom. The net was changed in 1982, but there is not likely to be enough data from the comparative fishing experiments to investigate impacts on cusk catchability. Most changes occurred for species up in the water column. Effects on species that might be similar to cusk, like skate, have not been investigated.

The summer RV survey is a stratified survey based on depth and geography. Sampling is through randomly selected stations in strata, and the standard tow is 30 min, but 20 min is acceptable. Sampling design has been consistent since 1970. Some changes have been made

in sampling intensity, but this was not considered to be an important factor in this analysis. Depth range is generally 15 to 200 fathoms. Additional stations have been done on the slope (to 400 fathoms) since 1995. The distribution of the survey is Div. 4VWX and the Canadian portion of Div. 5Y. From 1970-1981, the vessel was a side trawler using a Yankee 36 trawl, but in 1982 this was changed to a stern trawler with a Western IIA trawl. The *CCGS Alfred Needler* has been in used since 1983.

In the Allowable Harm Assessment, the annual DFO RV survey was not considered to be a reliable index. It does sample sandy bottom, but the relationship to preferred habitat may not be linear. The modeling results that were presented assumed that the RV survey index is proportional to biomass, and this would have to be noted as a source of uncertainty. In determining sources of data, it is important to consider time series that provide enough information to say something meaningful.

We know that there were some changes in Div. 4VW related to productivity, but the population model for cusk assumes constant productivity.

Alternative modeling scenarios were suggested, including Div. 4X alone. Since the sentinel survey is conducted outside of Div. 4X, it would have to be left out. CPUE estimates were for Div. 4X only. It was considered likely that the halibut longline survey index would not contribute much to a model of just Div. 4X.

For the exponential growth model, it was suggested that the impact of just using the sentinel and halibut surveys should be explored to see what kind of recovery you could get. It was considered likely that the cusk population was probably a long way from density dependence.

It was suggested that the 4X CPUE from July to September should be used including suggestions for improvements.

There was general agreement to ask that the modelers try a model run with CPUE as the index, compared to model runs with the RV survey. If CPUE alone fits, attempts should be made to add the halibut survey (even though it may not add much).

Research recommendations can be discussed tomorrow, but these would not be incorporated into the Science Advisory Report.

Someone asked how the models use information other than the RV survey, as the results appear to reflect the variability in the RV survey. If you use Virtual Population Analysis (VPA), which adds up catch and compares to survey, old data does not matter much. Obviously, the cusk population model does something differently. Is it possible to get a model fit that does not look like the RV survey trends? I. Jonsen responded that the RV survey trend was different from the model. He suggested that we are trying to come up with an estimate of true cusk biomass given that there is error. A state-space model is used to estimate the true but unobservable biomass. We are not interested in absolute number of cusk, but we do want to know the trend in abundance. Modeling separates observation errors from the randomness in the true biomass. There is a certain amount of smoothing that is done, but you will see some fluctuation from year to year. This may be because we are not estimating observation error or process error well. This is a weakness of fit issue.

Recovery Potential Assessment: Addressing the Terms of Reference (Part I)
L. Harris, DFO Maritimes Science

Presentation Highlights:

Objectives 1 and 2: Status and Trends.
There is insufficient data to determine if there are distinct populations of cusk within Atlantic Canada.

- No evidence of spatially separated populations of cusk.
- No studies have been undertaken to compare cusk life history in different areas.
- SSIP data do not suggest recruitment pulses of multiple spawning components.
- No genetic research information is currently available in Atlantic Canada. A genetic study is underway.

Objectives 3 and 10: Amount and Type of Habitat Necessary for Survival and Recovery.
Cusk prefer rough bottom with boulders, rocks, or pebbles. They are occasionally found on mud but rarely on sand. Depth range is reported to be from about 20 m to 1,185 m, but it may be deeper. The largest set of cusk in the halibut industry survey was at 560 m. Sets with the highest CPUE peak between 400-600 m. Rough estimate of cusk's primary habitat is 100,000 km^2 (where cusk most frequently caught). The full range of cusk in Canadian waters, including areas of low occurrence, is much greater. Not much is known about juvenile habitat preference; this is a source of uncertainty. Habitat does not appear to be a limiting factor.

Objective 7: Residence Requirements.
Based on current knowledge of adults, cusk do not have any known dwelling-place similar to a den or nest during any part of their life cycle; hence, the concept of "residence" does not apply to cusk.

Discussion:

Someone noted that cusk had been found associated with coral reefs off southwestern Norway. A citation was requested, and it was debated whether this information should be used to supplement the information that had been presented in cusk habitat. It was decided that it would not be included in this summary of cusk habitat information, but a process for incorporating information brought forward by participants was to be developed for future RPA meetings.

The FishBase map was not considered to be very good, as it appeared to be based on presence only. It does not include absences, and this may bias results.

L. Harris was asked if she had looked at available ROPOS video footage. She responded that this data source had not been utilized for this assessment.

From the distribution maps, it was suggested that temperature does not appear to be a limiting factor for cusk.

It was unclear to participants how information from the lobster project might be used to supplement understanding of cusk habitat. L. Harris noted that there was not a lot of habitat information collected during the special sampling. However, the highest catch rates were in the rocky channel area of preferred depth range.

Someone asked whether it would be useful to say that cusk are found in areas that are not regularly trawled. It was agreed that this may not be particularly useful.

Methods for quantifying the catchability of cusk in different gear types was discussed, including catch per hook or per fishing trip.

Homework from Day One
For consideration within the RPA meeting:
- Expansion of bycatch estimates to LFA 41.
- Pro-rating for time in LFA 34.
- Sub-sampling of halibut survey index to just Div. 4X.

For consideration within the research documents:
- Catch rate standardization by subarea.
- Length frequencies from lobster data.
- Decadal length frequency groupings with distribution of fishery.

Day Two: November 28, 2007

K. Smedbol started Day Two by providing a brief summary of Day One. This was followed by a review of work that was to have been done overnight.

Updates to Modeling
I. Jonsen and T. Davies, DFO Maritimes Science

Presentation Highlights:

I. Jonsen and T. Davies had been given the task of fitting the model to the CPUE index from the longline fishery from 1986-2007. They also fit the model to the RV survey in Div. 4X alone for comparison. Resulting estimates of r were 0.128 (RV survey) and 0.154 (CPUE index). For both values of r, projections were similar, but a higher r gave better projections. However, they did not do a sensitivity analysis to see what effect higher catches would have.

Discussion:

When asked what was going on with catchability, presenters responded that it was still very small. It was noted that if the discard rate stayed constant, then this would apply to landings and not to mortality.

Participants wanted to return to the question of whether we should keep discards as a constant or count lobster discards in the landings cap, as this would makes a huge difference in managing the fishery. Presenters noted that if efforts were made to reduce bycatch, r would have more of a buffer around it. It was unclear where the fishery would be likely to expand into; for example, would they be more likely to move offshore. In the future, DFO should be better to be able to track bycatch and account for it. However, participants were not convinced that a reliable estimate of cusk bycatch would be available in the future.

It was suggested that DFO could try to improve at-sea sampling in the lobster fishery – not just for cusk but for cod also.

Presenters were asked if they had been able to build the halibut survey index into the revised model yet. They had not been able to.

It was noted that the catch rates that had been given to L. Harris, which included vessel 1, did show an increase more recently.

It was noted that the modeling was very sensitive to *r*. For example, with an *r* of 0.05, maximum sustainable yield (MSY) would be 2500 mt and if r were 0.1, MSY would be 4000 mt.

Options were discussed for next steps in the modeling. For example, we could ask the modelers to add the halibut longline survey index to the revised model.

Use of the RV survey index was also discussed. Options included: throwing it out or using it with lots of caveats. If it is thrown out, it was noted that we do lose 20 years worth of a time series. Many other species-at-risk assessments are conducted with less information; however, it was unclear what additional information it provided. For example, it still does not give us the carrying capacity (K). It is considered to be negatively biased, and there is no reason to think that it is a better index now then when it was throw out previously. It was agreed that the model outputs using the RV survey would not be included in the advice.

CPUE was then discussed. CPUE was also considered to be potentially negatively biased as cusk is not a directed fishery, though it does include preferred and non-preferred habitat. In addition, there have been changes in management measures, such as closures and caps, that may have had some influence. There may be increasing incentives to catch cusk, as it is receiving a better price relative to some other species. The cusk fishery was also felt to exhibit complex fishing behaviour, which changes through time and is hard to describe. CPUE is also the only index to show a continuing decline.

The halibut survey index was noted to look like CPUE using vessel class 1 in Div. 4X.

The use of 75th percentiles as the bounds of uncertainty in the projections was recommended.

The representation from DFO Maritimes Policy and Economics Branch requested that mid-range scenarios, i.e., landings between 750 mt and 0 mt, be explored. It was agreed that this could be done.

It was suggested that the more that the modeling results are used and referred to, the more it appears as though you have confidence in these results.

Recovery Potential Assessment: Addressing the Terms of Reference (Part II)
L. Harris, DFO Maritimes Science

Presentation Highlights:

Objective 3: Recovery Targets.
There are no estimates for historical or current abundance of cusk. The magnitude of any decline is also unknown. In light of the paucity of information, a reasonable target would be a stable or increasing trend in abundance indices. As there is no evidence for a reduction in cusk area occupied, a reasonable recovery target would be to maintain current distribution.

Objective 8: Sources of Mortality.
The only known major source of human-induced mortality is fishing mortality. Major potential sources of non-lethal harm are not known at this time and are not thought to be a concern. Landings between 2003 and 2006 ranged from 790 to 1063 mt, averaging 869 mt. In years where closures to cusk were in place, there would be some unreported mortality if cusk are

caught and discarded. Estimated fishing mortality was 220-460 mt in LFA 34 and 20 mt in LFA 41 in 2005/2006. The fishing mortality in the lobster fishery in other areas and other invertebrate fisheries is not known.

Objective 9: Increasing Productivity or Survivorship.
There are no known activities that could increase cusk productivity. Productivity and survivorship are not thought to be limiting.

Discussion:

The concept of recovery was discussed, including suggestions that recovery depends on what you want it to be, that it includes both space and time, and that it requires a firm science basis. It was suggested that the meeting would be unlikely to come up with a quantitative target for recovery, and that we would be likely to require an interim target. It was also suggested that the index used to evaluated progress would be the same one used to determine projections. It was noted that the model only reflected aggregate abundance.

Day Three: November 29, 2007

T. Worcester started Day Three with a brief summary of Day Two. The meeting then went straight into the review of the draft Science Advisory Report (SAR).

REVIEW OF THE SCIENCE ADVISORY REPORT

Context

The following wording was suggested: "Cusk was designated as threatened by COSEWIC, largely on the basis of declines in the DFO RV survey." Also to be included in the Rationale for Assessment.

Species Biology and Ecology

When asked whether she wanted to add results from ageing studies into the report, L. Harris responded by saying that there were no conclusive results yet. They would still have to verify results, though there may be no errors as cusk seemed straightforward to age.

The following wording was suggested: "There is preliminary information that the length at maturity in females may have changed, and studies are currently underway to investigate this further." It was noted that something similar has been seen in Div. 4X haddock, where the age at maturity has stayed the same while the length at maturity has changed, but the trend is similar for both sexes.

There was some further discussion on whether statements related to the apparent change in the length at maturity for females should be included in the SAR. One of the reviewers noted that this could be included in the background section without influencing the advice, as it was an interesting finding. Oldham's (1966) work indicates that males grow a bit faster than females. There are currently more males than females (60/40). This means that females are growing more slowly. On a virgin stock, females would be older. As this is fished down, males and females could be acting like 2 different stocks, i.e., there may be reason for flip-flop. It is an interesting life-history feature and it should not be glossed over, as it would have an impact on the fishery. However, in the end, it was decided that this preliminary finding would not be

appropriate to include in the SAR, as participants were not comfortable with the idea that it could be used as the basis for management changes. This finding will be identified as a research priority and length at maturity will be collected annually.

It was noted that the fishery is size selective, not age selective, and so you are eventually going to have fewer females. It was also noted that the 60/40 male to female ratio was based on sampling with limited sample size.

It was suggested that the sentence on cusk prey be reworded.

Current Status and Trends

The following wording was recommended: "There are no discontinuities in the spatial distribution of cusk.", and "Because the surveys do not sample the preferred habitat or depths in the range of cusk.".

It was suggested that we should say something about why we are concerned about the halibut survey protocols: "i.e., bait and sample coverage".

Surveys should be listed: "(halibut fixed station survey and 4VsW sentinel surveys)".

Someone asked whether the statement "Management measures (e.g., trip limits, overall caps, and bycatch percentages) may have caused a reduction in catch rates" was accurate. FAM agreed that this did reflect current management practice.

Someone questioned whether catch rates are considered proportional to abundance, and it was noted that they better be since they were used as the basis for the model.

When asked whether we should say something about which survey was used by COSEWIC, I. Jonsen noted that COSEWIC did not just look at the RV survey though they did use it for calculations of decline.

It was suggested that there should be one figure for all abundance indices, and they should be scaled to the average during the longest period of overlap. The one that is favoured, i.e., the CPUE index, should be bold. Indices should include:

- RV survey
- 4VsW sentinel survey – 1995 to 2003?
- halibut survey
- NMFS survey
- CPUE

It was suggested that the sense of scale needs to be explicit when talking about distribution.

The following wording was suggested: "There has been no reduction in the **range** of cusk in Canadian waters. The percent of stations where cusk was caught in the halibut fixed station survey, which covers the Grand Banks to the Gulf of Maine, has fluctuated without trend since it started in 1998. At a smaller scale, cusk are captured in most groundfish longline trips. Cusk are also caught regularly in lobster fisheries where fisheries overlap with cusk distribution. There has been no change in the range or prevalence of cusk in the groundfish longline fishery in Div. 4X (Figure 13). Cusk do not appear to have disappeared from any areas where they have historically been caught.".

Use of distribution information from the RV survey was questions, as it might make it look like something was happening when it has not.

It was suggested that figures 9 and 13 be merged into 1 graph.

Targets for Recovery

There was consensus that an absolute biomass target may not be an achievable goal. The possibility of an interim target was discussed. It was suggested that efforts be made to develop an abundance index that more accurately reflects cusk abundance across its range.

Population Trajectory under Varying Conditions

During the discussion, I. Jonsen and T. Davies tried a new simulation and produced a new graph showing the probability of recovery after 15 years under different levels of exploitation and different recovery targets. They clarified that the bottom axis represented landings and not total mortality. Participants agreed that this graph was easier to understand.

It was noted that uncertainties and caveats still applied, and there had not been much scrutiny of the model. However, we have agreed to use this data at the meeting. It was suggested that this be considered a preliminary model, and the limitations of using aggregates for age structured populations be recognized in the sources of uncertainty.

I. Jonsen noted that the modeling results represented a summary of many thousands of runs. He noted that it is presented graphically as a median estimate, so there are error bars. He asked whether only the 80% line should be shown, or whether the 25, 50, 75% lines should also be shown. Participants agreed that this should be attempted if it did not make the graph too complex.

Additional details on the range and confidence intervals will be included in the research document.

Results of the modeling seemed reasonable with current information. It essentially says that there is a 50/50 chance of staying stable with landings of approximately 1000 mt.

Clarification was requested on the use of 15 years as the time to recovery. This was chosen because it is the generation time and 3 times this, or 45 years, seemed unreasonable for management purposes. Participants generally agreed with this approach.

The inclusion of three scenarios was questioned, but participants felt this would be valuable.

It was suggested that percentages be used rather than 1.5 and 2 times.

It was asked whether uncertainty in the estimate of r could be better reflected. However, doing this was considered to be more complicated.

Sources of Mortalities

Landings information should be updated.

Include years 2003, 2004, 2005, 2006, and then average. Explain why 2003 was not used.

It was noted that the southern range for the population extends into U.S. waters and represents a potential sources of mortality.

Habitat-Related Threats

It was suggested that habitat threats and productivity measures could be combined.

Caution was recommended when disregarding potential habitat threats. We know that there are threats to habitat and these can not be ignored; however, there were not expected to be major threats.

Mitigation Measures and Alternatives

Inclusion of quotas in the list was discussed. Use of quotas was considered to be a big step, but it was an option.

The role of ecolabeling and Marine Stewardship Council (MSC) certification was discussed briefly. These may have an effect on overall mortality of cusk.

Conclusions

It was suggested that it would be better to have a range for decline. However, agreement could not be reached.

NEXT STEPS

Working papers are to be revised and submitted as research documents. All figures that are used in the SAR should be included in the research documents with more detailed descriptions. Participants agreed that L. Harris could exert some flexibility in the headings for her research document now that the SAR had been completed. I. Jonsen's paper should include the revised modeling results that were included in the SAR. Also, the research document should include the rationale for what we considered and why we included what we did in the SAR. Inclusion of other modeling scenarios was considered to be acceptable. L. Harris' paper should include at a minimum the information that is required to support the SAR, but additional information was considered optional. Describe what was done, and explain what was suggested.

The SAR will be run through an editorial meeting and circulated to participants when completed. It will eventually be posted to the CSAS website www.dfo-mpo.gc.ca/csas

CLOSING REMARKS

The meeting ended with a round of closing remarks from all participants.

One DFO Science participant wanted to further explore the linkages between the stock assessment process and the RPA process. Another participant noted that the data for cusk is not great, and there is no strong mechanism to improve it in the future. It is hard to conduct an RPA and manage a threatened species when the data does not exist and there is no mechanisms to collect it. An NGO participant expressed concern on how DFO Science decides when to use which data sources. It was suggested that including statements about the lack of confidence in DFO surveys might erode public confidence. It was recommended that

explanations be provided whenever such statements are made. A FAM participant expressed concern that if cusk is listed as threatened that it would mean cusk could not be sold and; therefore, may increase the incidence of discarding at sea. We will have to be careful not to suggest measures that may lead to additional harm to cusk, and it should be recognized that the information DFO gets from landings information is more accurate than discard information. The participant from Policy and Economics Branch noted that what goes into the SAR will inform and influence the development of management scenarios. Future discussions will be required about what is useful for consultations and socio-economic analysis. A DFO Science participant wanted to reiterate that the longline CPUE needs to be reviewed, including effects of tonnage class and season. The shark fisheries all use these for abundance indices. Another participant asked whether there was a way to implement a decision-tree approach. Finally, the last participant noted that this is a data poor situation, but not the most data poor situation. There are other species for which much less information is available. Data paucity is relative. Future discussions will be required on methodologies to help deal with uncertainties; however, this meeting was seen as progress.

REFERENCES

COSEWIC, 2003. COSEWIC Assessment and Status Report on the Cusk *Brosme brosme* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

DFO, 2004. Allowable Harm Assessment for Cusk in Atlantic Canada. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/044.

Harris, L.E., P.E. Comeau, and D.S. Clark. 2002. Evaluation of Cusk (*Brosme brosme*) in Canadian Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/104.

Oldham, W.S. 1966. Some Aspects of the Fishery and Life History of the Cusk (*Brosme brosme*) (Muller). Thesis (M.Sc.) - University of Western Ontario.

APPENDICES

Appendix 1. Terms of Reference

Recovery Potential Assessment of 4VWX5 Cusk
Maritimes Region Science Advisory Process

Hachey Boardroom, Biological Station
St. Andrews, NB

27–29 November 2007

TERMS OF REFERENCE

Context

Atlantic cusk was designated as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May 2003. As a consequence of the *Species at Risk Act* (SARA) listing process conducted by DFO during 2004/05, the species was returned to COSEWIC for further consideration. COSEWIC's subsequent deliberations resulted in a confirmation of its original assessment. Therefore, the species is once again being considered for listing on Schedule 1 of SARA.

If listed under SARA as threatened, cusk would be subject to the automatic prohibitions and would benefit from a recovery strategy and subsequent action plan(s). However, Section 73 (2) of SARA authorizes competent Ministers to permit otherwise prohibited activities affecting a listed wildlife species, any part of its critical habitat, or the residences of its individuals. Such permission can only be granted under certain conditions: 1) if the activity is scientific research relating to the conservation of the species, 2) benefits the species or is required to enhance its chances of survival in the wild, or 3) affecting the species is incidental to the carrying out of the activity.

Decisions on the potential for permitting of incidental harm and in support of recovery planning are informed by the impact of human activities on the species, alternatives and mitigation measures to these and the potential for recovery. An evaluation framework, consisting of three phases (species status, evaluation of the scope for management to facilitate recovery, and mitigation) has been established by DFO to inform recovery and permitting processes.

Objectives

Phase I: Assess Current Species Status

1. Evaluate present species status for abundance, range and number of populations.
2. Evaluate recent species trajectory for abundance, range and number of populations.
3. Estimate the amount and type of habitat that is necessary for survival and recovery.
4. Estimate potential recovery targets (including abundance and distribution).
5. Project expected population trajectory over three generations (or other biologically reasonable timeframe) given current population dynamics parameters and associated uncertainties, assuming only natural mortality.
6. Estimate how time to recovery targets would change at various levels of mortality/productivity.
7. Evaluate Residence Requirements, if any.

Phase II: Scope for Management to Facilitate Recovery

8. Quantify, to the extent possible, the risk (including likelihood, severity and uncertainty) of each major potential source of mortality / harm identified in the pre-COSEWIC RAP or COSEWIC Status Report. Where it is not possible to determine the absolute magnitude of each risk, determine the relative impact of these risks on survival and recovery.
9. Inventory, to the extent possible, all reasonable and feasible activities that could increase productivity or survivorship.
10. Evaluate to the extent possible the likelihood that habitat is currently, or is likely to become, a limiting factor to achieving recovery targets identified in 4.
11. Assess, to the extent possible, the magnitude by which current threats to habitat have reduces habitat quantity and quality.

Phase III: Scenarios for Mitigation and Alternative to Activities

To the extent possible with the information available,

12. Inventory all feasible measures to minimize the impacts of activities in task 8 and 11.
13. Inventory all reasonable alternatives to the activities in tasks 8 and 11, but with potential for less impact (e.g., changing gear in fisheries causing bycatch mortality, relocation of activities harming critical habitat).
14. Document the expected reduction in risk to survival and recovery if the mitigation measures described in task 12 were implemented.
15. Document the expected reduction in risk to survival and recovery if the alternatives to the activities described in task 13 were implemented.

Outputs

- CSAS Science Advisory Report
- CSAS Proceedings
- CSAS Research Document

Participation

- DFO Maritimes and Newfoundland Science, Fisheries & Aquaculture Management, Oceans & Habitat, Policy and Economics, and SARA Office
- Aboriginal Communities / Organizations
- Provinces of NS, NB, and NL
- NS, NB, and NL Fishing Industry
- NGOs (WWW and EAC)
- External Reviewers
- NOAA/NMFS

Appendix 2. Agenda

Recovery Potential Assessment of 4VWX5 Cusk
Maritimes Region Science Advisory Process

Hachey Boardroom, Biological Station
St. Andrews, NB

27–29 November 2007

DRAFT AGENDA

27 November 2007– Tuesday

09:00 -- 09:15	Welcome and Introduction (Chairs)
09:15 -- 10:00	Phase I analyses
10:00 -- 10:15	Break
10:15 -- 12:00	Phase I analyses continued
12:00 -- 13:00	Lunch
13:00 -- 15:00	Phase II analyses
15:00 -- 15:15	Break
15:15 -- 17:00	Phase II analyses continued

28 November 2007 – Wednesday

09:00 -- 10:00	Phase III analyses
10:00 -- 10:15	Break
10:15 -- 12:00	Further analyses identified from first day
12:00 -- 13:00	Lunch
13:00 – 15:00	Review of Draft of Science Advisory Report
15:00 -- 15:15	Break
15:15 -- 17:00	Review of Draft of Science Advisory Report

29 November 2007 – Thursday

09:00 -- 12:00	Completion of Review of Science Advisory Report

12:00 Adjournment

Appendix 3. List of Participants

Recovery Potential Assessment of 4VWX5 Cusk
Maritimes Region Science Advisory Process

Hachey Boardroom, Biological Station
St. Andrews, NB

27–29 November 2007

ATTENDEES

Name	Affiliation
Annand, Chris	DFO Maritimes / FAM
Boudreau, Cyril	NS Fisheries and Aquaculture
Boyd, Catherine	Clearwater Seafoods
Cheney, Trisha	Maine Dept. of Marine Resources
Clark, Don	DFO Maritimes / SABS
Clark, Kirsten	DFO Maritimes / SABS
Comeau, Peter	DFO Maritimes / PED
Damon-Randall, Kimberly	NOAA, NMFS
Davies, Trevor	DFO Maritimes / PED
Emberley, Jamie	DFO Maritimes / SABS
Facey, Amanda	Maritimes Aboriginal Peoples Council
Ford, Jennifer	Ecology Action Centre (EAC)
Fuller, Susanna	Ecology Action Centre (EAC)
Gavaris, Stratis	DFO Maritimes / SABS
Hanke, Alex	DFO Maritimes / SABS
Hansen, Jorgen	DFO Maritimes / FAM
Harris, Lei	DFO Maritimes / SABS
Jamieson, Jim	DFO Maritimes / FAM
Johnston, Marc	NB Dept of Fisheries
Jonsen, Ian	DFO Maritimes / PED
London, Evelyn	Oromocto First Nation
MacIntosh, Robert	DFO Maritimes / P&E
McNeeley, Joshua	Maritimes Aboriginal Peoples Council
Minto, Coilin	Dalhousie University, Biological Sciences
Newbould, Andrew	DFO Maritimes / O&H
O'Brien, Loretta	NOAA, NMFS
Porter, Julie	DFO Maritimes / SABS
Power, Mike	DFO Maritimes / SABS
Smedbol, Kent (Co-chair)	DFO Maritimes / SABS
Spence, Koren	DFO Maritimes / SARA
Stephenson, Rob	DFO Maritimes / SABS
Stone, Heath	DFO Maritimes / SABS
Van Eeckhaute, Lou	DFO Maritimes / SABS
Wang, Yanjun	DFO Maritimes / SABS
Waters, Christa	DFO Maritimes / SABS
Worcester, Tana (Co-chair)	DFO Maritimes / CSA